CLAIMS

[0072] What is claimed as new and desired to be protected by Letters Patent of the United States is:

1. A pixel cell comprising:

a photo-conversion device;

a storage node switchably coupled to the photo-conversion device for receiving charge from the photo-conversion device via a shutter transistor,

a capacitor electrically connected to a gate of the shutter transistor and the storage node;

a sensing node switchably coupled to the storage node for receiving the charge from the storage node; and

an anti-blooming circuit electrically connected to the photo-conversion device for selectively draining charge from the photo-conversion device.

2. The pixel cell of claim 1, further comprising a readout and reset circuit electrically connected to the sensing node to output the charge accumulated at the sensing node.

3. The pixel cell of claim 2, wherein the readout and reset circuit comprises:

a reset transistor electrically connected to the sensing node;

a source-follower transistor, wherein the source follower transistor comprises a gate, wherein the source follower gate is electrically connected to the sensing node; and

a row select transistor electrically connected to the source-follower transistor.

4. The pixel cell of claim 3, wherein at least one of the sensing node, reset transistor, source follower transistor, and row select transistor are shared with at least one other pixel cell.

5. The pixel cell of claim 3, wherein the anti-blooming circuit, reset transistor and source follower transistor are electrically connected to a common voltage source.

6. The pixel cell of claim 1, wherein the photo-conversion device is a pinned photodiode.

7. The pixel cell of claim 1, wherein the sensing node is a floating diffusion node.

8. The pixel cell of claim 1, wherein the anti-blooming circuit is an anti-blooming transistor.

9. The pixel cell of claim 8, wherein the sensing node is switchably coupled to the storage node by a transfer transistor, wherein the transfer transistor and the anti-blooming transistor each comprise respective gates, and wherein the gate of the anti-blooming transistor is electrically connected to the gate of the transfer transistor.

10. The pixel cell of claim 1, wherein the sensing node is switchably coupled to the storage node by a transfer transistor.

11. The pixel cell of claim 1, wherein the storage node is a doped region of a second conductivity type below a surface of a substrate.

12. The pixel cell of claim 1, wherein the capacitor is above a substrate.

13. The pixel cell of claim 1, wherein the capacitor is a polypropylene capacitor.

14. A pixel cell comprising:

a photo-conversion device;

a storage node switchably coupled to the photo-conversion device for receiving charge from the photo-conversion device via a shutter transistor, a gate of the shutter transistor being electrically connected to the storage node;

a first barrier region adjacent to the storage node, the barrier region being electrically connected to the gate of the shutter transistor;

a sensing node switchably coupled to the storage node for receiving the charge from the storage node; and

an anti-blooming circuit electrically connected to the photo-conversion device for selectively draining charge from the photo-conversion device.

15. The pixel cell of claim 14, further comprising a readout and reset circuit electrically connected to the sensing node to output the charge accumulated at the sensing node.

16. The pixel cell of claim 15, wherein the readout and reset circuit comprises:

a reset transistor electrically connected to the sensing node;

a source-follower transistor, wherein the source follower transistor comprises a gate, wherein the source follower gate is electrically connected to the sensing node; and

a row select transistor electrically connected to the source-follower transistor.

17. The pixel cell of claim 16, wherein at least one of the sensing node, reset transistor, source follower transistor, and row select transistor are shared with at least one other pixel cell.

18. The pixel cell of claim 16, wherein the anti-blooming circuit, reset transistor and source follower transistor are electrically connected to a common voltage source.

19. The pixel cell of claim 14, wherein the photo-conversion device is a pinned photodiode.

20. The pixel cell of claim 14, wherein the sensing node is a floating diffusion node.

21. The pixel cell of claim 14, wherein the anti-blooming circuit is an anti-blooming transistor.

22. The pixel cell of claim 21, wherein the sensing node is switchably coupled to the storage node by a transfer transistor, wherein the transfer transistor and the anti-blooming transistor each comprise respective gates, and wherein the gate of the anti-blooming transistor is electrically connected to the gate of the transfer transistor.

23. The pixel cell of claim 14, wherein the sensing node is switchably coupled to the storage node by a transfer transistor.

24. The pixel cell of claim 14, wherein the storage node is a doped region of a second conductivity type below a surface of a substrate.

25. The pixel cell of claim 14, wherein the first barrier region is a heavily doped region of a first conductivity type below a surface of a substrate.

26. The pixel cell of claim 14, wherein the barrier region is between the photo-conversion device and the storage node.

27. The pixel cell of claim 14, further comprising a second barrier region between the barrier region and the sensing node.

28. The pixel cell of claim 27, wherein the second barrier region is a heavily doped region of a first conductivity type below a surface of a substrate.

29. A pixel sensor array comprising:

at least one subset of pixel cells at a surface of a substrate, the at least one subset comprising:

at least two photo-conversion devices;

at least two anti-blooming transistors, each anti-blooming transistor being electrically connected to a respective photo-conversion device for selectively draining charge from the respective photo-conversion device;

at least two storage nodes switchably coupled to a respective photo-conversion device for receiving charge from the respective photo-conversion device via a respective shutter transistor, a gate of

each shutter transistor being electrically connected to a respective storage node; and

a sensing node switchably coupled to the storage nodes for receiving the charge from the storage nodes via respective transfer transistors, a gate of each transfer transistor being electrically connected to a respective gate of an anti-blooming transistor.

30. The array of claim 29, wherein the at least one subset of pixel cells further comprises a reset and readout circuit electrically connected to the sensing node.

31. The array of claim 30, wherein the reset and readout circuit comprises:

a reset transistor electrically connected to the floating diffusion node for resetting the voltage on the sensing node;

a source-follower transistor electrically connected to the reset transistor for receiving charge from the sensing node; and

a row select transistor electrically connected to the source-follower transistor for outputting a signal produced by the source follower transistor.

32. The array of claim 31, wherein the at least two anti-blooming transistors, the reset transistor, and the source follower transistor are electrically connected to a common voltage source.

33. The array of claim 29, wherein the sensing node is a floating diffusion node.

34. The array of claim 29, wherein the storage nodes are doped regions of a second conductivity type below the surface of the substrate.

35. The array of claim 29, wherein the at least one subset of pixel cells further comprise at least two barrier regions, each barrier region being between a respective photo-conversion device and a respective storage node, and wherein the barrier region is a doped region of a first conductivity type below a surface of the substrate.

36. The array of claim 29, wherein the at least one subset further comprises at least two capacitors, each capacitor electrically connected to a respective shutter gate and a respective storage node.

37. The array of claim 36, wherein the at least two capacitors are above the substrate.

38. The array of claim 36, wherein the at least two capacitors are polypropylene capacitors.

39. A processor-based system comprising:

a processor; and

an imager coupled to the processor, the imager comprising an array of pixel cells, at least one of the pixel cells comprising:

a photo-conversion device;

a storage node switchably coupled to the photo-conversion device for receiving charge from the photo-conversion device via a shutter transistor,

a capacitor electrically connected to a gate of the shutter transistor and the storage node;

a sensing node switchably coupled to the storage node for receiving the charge from the storage node; and

an anti-blooming circuit electrically connected to the photo-conversion device for selectively draining charge from the photo-conversion device.

40. A processor-based system comprising:

a processor; and

an imager coupled to the processor, the imager comprising an array of pixel cells, at least one of the pixel cells comprising:

a photo-conversion device;

a storage node switchably coupled to the photo-conversion device for receiving charge from the photo-conversion device via a shutter transistor, a gate of the shutter transistor being electrically connected to the storage node;

a first barrier region adjacent to the storage node, the barrier region being electrically connected to the gate of the shutter transistor;

a sensing node switchably coupled to the storage node for receiving the charge from the storage node;

a second barrier region between the storage node and the sensing node; and

an anti-blooming circuit electrically connected to the photo-conversion device for selectively draining charge from the photo-conversion device.

41. An integrated circuit comprising:

an array of pixel cells, each pixel cell comprising:

a photo-conversion device;

a storage node switchably coupled to the photo-conversion device for receiving charge from the photo-conversion device via a shutter transistor,

a capacitor electrically connected to a gate of the shutter transistor and the storage node;

a sensing node switchably coupled to the storage node for receiving the charge from the storage node; and

an anti-blooming circuit electrically connected to the photo-conversion device for selectively draining charge from the photo-conversion device.

42. The integrated circuit of claim 41, further comprising a readout and reset circuit electrically connected to the sensing node to output the charge accumulated at the sensing node.

43. The integrated circuit of claim 42, wherein the sensing node and readout and reset circuit are shared between at least two pixel cells of the array.

44. An integrated circuit comprising:

an array of pixel cells, each pixel cell comprising:

a photo-conversion device;

a storage node switchably coupled to the photo-conversion device for receiving charge from the photo-conversion device via a shutter transistor, a gate of the shutter transistor being electrically connected to the storage node;

a first barrier region adjacent to the storage node, the barrier region being electrically connected to the gate of the shutter transistor;

a sensing node switchably coupled to the storage node for receiving the charge from the storage node; and

an anti-blooming circuit electrically connected to the photo-conversion device for selectively draining charge from the photo-conversion device.

45. The integrated circuit of claim 44, further comprising a second barrier region between the storage node and the sensing node.

46. The integrated circuit of claim 44, further comprising a readout and reset circuit electrically connected to the sensing node to output the charge accumulated at the sensing node.

47. The integrated circuit of claim 46, wherein the sensing node and readout and reset circuit are shared between at least two pixel cells of the array.

48. A method of operating a pixel cell of an image sensor, the method comprising:

receiving light at a photo-conversion device;

directing excess charge from the photo-conversion device via an anti-blooming transistor;

transferring charge from the photo-conversion device to a storage node by operating a shutter gate;

transferring the charge from the storage node to a floating diffusion node by operating a transfer gate, wherein when the transfer gate is operated, the anti-blooming gate is also operated; and

reading out the charge on the floating diffusion node.

49. The method of claim 48, further comprising storing the charge in a capacitor, the capacitor being electrically connected to the storage node.

50. The method of claim 48, wherein the act of transferring the charge from the photo-conversion device further comprises transferring the charge through a barrier region within a substrate.

51. A method of operating a pixel cell of an image sensor, the method comprising:

receiving light at a photo-conversion device;

directing excess charge from the photo-conversion device via an anti-blooming transistor;

transferring charge from the photo-conversion device to a storage node within the substrate by operating a shutter gate to lower a potential barrier in a first barrier region;

transferring the charge from the storage node to a floating diffusion node by operating a transfer gate; and

reading out the charge on the floating diffusion node.

52. The method of claim 51, further comprising operating a gate of the anti-blooming transistor when the transfer gate is operated.

53. The method of claim 51, wherein the act of transferring the charge from the storage node to a floating diffusion node further comprises lowering a potential barrier in a second barrier region.

54. A method of operating a pixel of an image sensor, the method comprising: 10

generating and accumulating charge in a photo-conversion device;

when the photo-conversion device is saturated with charge, directing excess charge from the photo-conversion device via an anti-blooming gate;

transferring the charge from the photo-conversion device to a storage device by operating a gate of a shutter transistor, the storage device comprising a storage node electrically connected to a capacitor, the capacitor being electrically connected to the gate of the shutter transistor;

transferring the charge from the storage device to a floating diffusion node by operating a transfer gate; and

reading out the charge on the floating diffusion node.

55. The method of claim 54, further comprising operating a gate of the anti-blooming transistor when the transfer gate is operated.

56. A method of operating a subset of pixel cells of an imager, wherein the subset comprises at least two pixel cells, the method comprising:

accumulating first charge in a first photo-conversion device;

when the first photo-conversion device is saturated with the first charge, directing an excess of the first charge from the photo-conversion device via a first anti-blooming transistor;

transferring the first charge from the first photo-conversion device to a first storage node;

transferring the first charge from the first storage node to a floating diffusion node by operating a gate of a first transfer transistor, wherein the first transfer transistor gate is electrically connected to a gate of the first anti-blooming transistor, wherein when the first transfer transistor gate is operated the first anti-blooming transistor gate is operated;

reading out the first charge from the floating diffusion node;

accumulating a second charge in a second photo-conversion device;

when the second photo-conversion device is saturated with the second charge, directing an excess of the second charge from the photo-conversion device via a second anti-blooming transistor;

transferring the second charge from the second photo-conversion device to a second storage node within a substrate of a second pixel;

transferring the second charge from the second storage node to the floating diffusion node by operating a gate of a second transfer

transistor, wherein the second transfer transistor gate is electrically connected to a gate of the second anti-blooming transistor, wherein when the second transfer transistor gate is operated the second anti-blooming transistor gate is operated; and

reading out the second charge from the floating diffusion node.

57. The method of claim 56, wherein the act of reading out the first charge comprises operating a gate of a row select transistor and applying the first charge on the floating diffusion node to a gate of a source follower transistor, and wherein the act of reading out the second charge comprises operating the gate of the row select transistor and applying the second charge on the floating diffusion node to a gate of a source follower transistor.

58. The method of claim 56, wherein the first and second photo-conversion devices accumulate charge during an integration period, wherein the act of transferring the first and second charges from the first and second photo-conversion devices, respectively, comprises operating respective first and second shutter gates, and wherein the first and second shutter gates remain on during the integration period.

59. The method of claim 56, further comprising:

accumulating third charge in a third photo-conversion device;

when the third photo-conversion device is saturated with the third charge, directing an excess of the third charge from the photo-conversion device via an anti-blooming gate;

transferring the third charge from the third photo-conversion device to a third storage node within a substrate;

transferring the third charge from the third storage node to a floating diffusion node by operating a gate of a third transfer transistor, wherein the third transfer transistor gate is electrically connected to a gate of the third anti-blooming transistor, wherein when the third transfer transistor gate is operated the third anti-blooming transistor gate is operated;

reading out the third charge from the floating diffusion node;

accumulating a second charge in a second photo-conversion device;

when the fourth photo-conversion device is saturated with the fourth charge, directing an excess of the fourth charge from the photo-conversion device by operating an anti-blooming gate;

transferring the fourth charge from the fourth photo-conversion device to a fourth storage node within a substrate of a fourth pixel;

transferring the fourth charge from the fourth storage node to the floating diffusion node by operating a gate of a fourth transfer transistor, wherein the fourth transfer transistor gate is electrically connected to a gate of the fourth anti-blooming transistor, wherein when the fourth transfer transistor gate is operated the fourth anti-blooming transistor gate is operated; and

reading out the fourth charge from the floating diffusion node.

60. The method of claim 59, wherein the acts of transferring occur on half clock cycles.